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AUTHOR(S):

Kosaka, Yasuyuki; Saikia, Bhaskar; Rai, C. K.; Hage, Komo; Asada, Haruhisa; Hui, Tag; Riba, Tomo; Ando, Kazuo

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ORIGINAL ARTICLE

On the introduction of paddy rice cultivation by swiddeners in Arunachal Pradesh, India

Yasuyuki Kosaka^{1*}, Bhaskar Saikia², C. K. Rai³, Komo Hage⁴, Haruhisa Asada⁵, Tag Hui², Tomo Riba⁶ and Kazuo Ando⁷

¹ Graduate School of Asian and African Area Studies, Kyoto University, Kyoto 606-8501, Japan

² Faculty of Life Sciences, Rajiv Gandhi University, Itanagar, Arunachal Pradesh 791112, India

³ C. K. Service, Naharlagun, Arunachal Pradesh 791112, India

⁴ Government School of Ziro, Arunachal Pradesh 791112, India

⁵ Faculty of Letters, Nara Women's University, Nara 630-8506, Japan

⁶ Faculty of Environmental Sciences, Rajiv Gandhi University, Itanagar, Arunachal Pradesh 791112, India

⁷ Center for Southeast Asian Studies, Kyoto University, Kyoto 606-8501, Japan

* Corresponding author: kosaka@asafas.kyoto-u.ac.jp

ABSTRACT The transformation of land from swidden based to permanent agriculture is an important issue related to the sustainable livelihood and land use system of people in mountain environments. This paper reports the introduction of paddy rice cultivation and its consequences in four swiddener communities in Arunachal Pradesh, India, by focusing on cultivation techniques. The Indian government introduced paddy rice cultivation to Arunachal Pradesh in the 1950s by teaching the required techniques and supplying seed and agricultural tools. However, few swiddeners began rice cultivation because they disliked working in muddy paddies that could not produce non-rice crops. During the “green revolution” in the 1970s, many people decided to create paddy fields after observing the remarkably high yield of new rice varieties. Over 60 years of trial and error, many swiddener communities have developed a unique cultivation system suited to their local environment, while often learning from their neighboring communities of Ahom and Apatani that already practiced paddy rice cultivation. The paddy field has become a symbol of wealth and social status because of the high and stable yield of paddy rice and escalating land prices. However, the communities usually continue some aspects of swidden cultivation, because only a limited amount of land is suitable for paddy rice, people need non-rice crops, or because older people prefer swidden cultivation work and the taste of upland rice. This case study shows the importance of local needs and knowledge of skilled farmers in swidden transformation.

Key words: cultivation techniques, green revolution, Himalaya, local knowledge, swidden transformation

INTRODUCTION

Swidden and paddy rice cultivation are ancient and important land use systems in the tropics. However, current political, legal, and economic factors such as the prohibition of swidden cultivation, land reform, logging, large-scale land development, exclusionary conservation zoning, and resettlement have led to the replacement of swidden cultivation by other land use systems (Mertz et al. 2009). In addition, paddy rice cultivation is noted for its high productivity and sustainability, ability to mitigate soil erosion, and its function as a water reservoir (Kadono and Yuma 1995).

Accordingly, attempts have been made to introduce paddy rice cultivation into swidden communities as an alternative form of permanent agriculture. Some people achieved steady rice production in the newly introduced paddy field, but others failed because they lacked suitable

land, knowledge, techniques, and incentives (Rasul and Thapa 2003). The transformation of swidden to permanent agriculture stands as an important issue related to the human needs of swidden communities and the management of mountain environments. The transformation process varies by region (Rasul and Thapa 2003) and the consequences of the transformation are poorly understood (Mertz et al. 2009).

The area now known as Arunachal Pradesh, India, was previously known as the North East Frontier Agency until 1972. Here, the government has promoted the introduction of paddy rice cultivation to improve food production since 1947 when India became independent and this new cultivation technique has resulted in increased rice production (Purkayastha 2008). The cost of making terraces and irrigating excludes all but wealthy farmers from owning paddy fields (Ramakrishnan 1992).

Earlier reports on the introduction of paddy rice cultivation in Arunachal Pradesh were written from the viewpoint of agronomy, economy, or political science. This paper, however, focuses on the dynamics of human-environment interaction during swidden transformation, and on the swiddeners' ideas and activities. The key questions of this study are (1) how do swiddeners describe their own history including swidden transformation, and (2) what techniques and terms did swiddeners adopt during the introduction of paddy rice cultivation. The objective of this study is to draw a detailed picture of swidden transformation in Arunachal Pradesh, and to consider the sustainable method of gaining a livelihood and the related land use system in this mountain environment.

STUDY SITE AND METHODS

Study site

The sites studied were in villages in the Lakhimpur District in Assam, in the Upper and Lower Subansiri districts, the West, East, and Upper Siang districts, and the Papum Pare District in Arunachal Pradesh (Fig. 1, Table 1).

The climate features three seasons, a warm, dry summer (March–May), a monsoon season (June–September), and a cool, dry winter (October–February). About 85 % of the total annual rainfall occurs during the monsoon (Table 1). The average maximum and minimum temperature was 25.8°C and 15.7°C (Purkayastha 2008).

The study involved surveys of the communities of Ahom, Mishing, Tagin, Galo, Minyong, Nishi, and Apatani (Fig. 1, Table 1). Ahom and Mishing lie in the Brahmaputra River floodplain of Assam. The Tai-speaking people of Ahom (Shintani 1998) had migrated to eastern Assam in the 13th century and established the Ahom kingdom, which last-

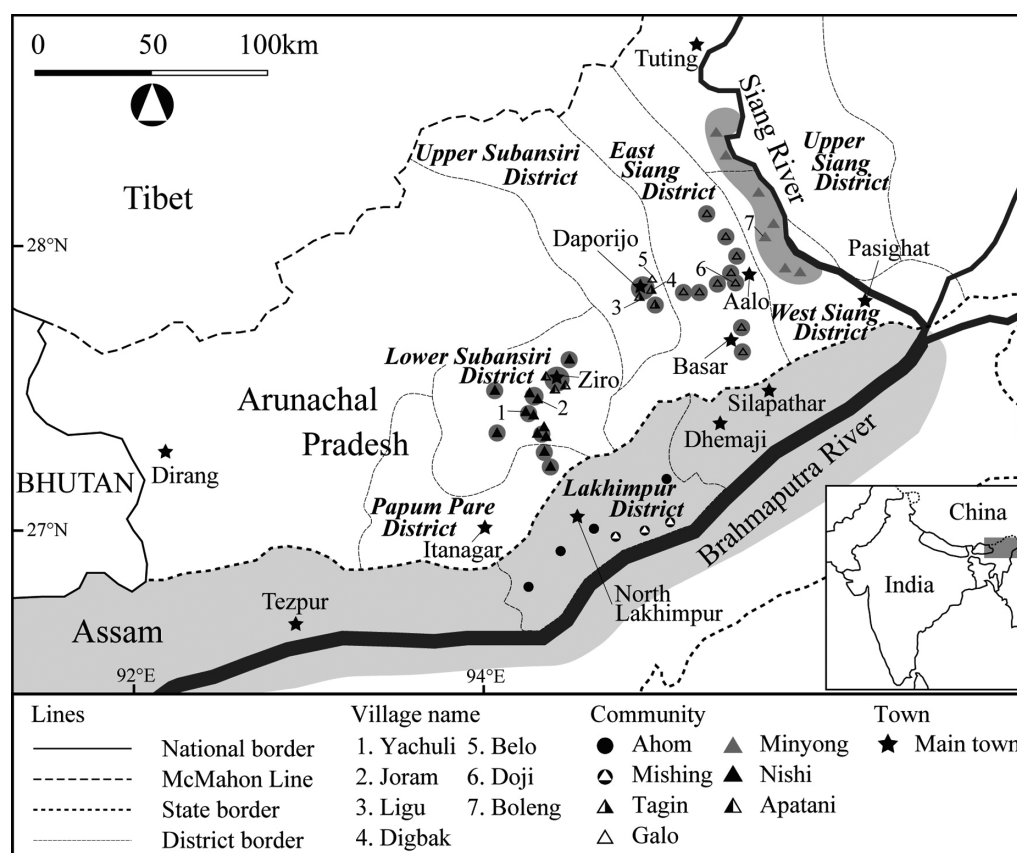


Fig. 1. Locations of study sites in Arunachal Pradesh and Assam, India. Various icons designate the locations of different communities. The light gray zone along the Brahmaputra River represents the floodplains, home of the Ahom and Mishing communities. The pale gray zone along the Siang River is the gorge slope, home of the Minyong community, and the dark gray circles indicate mountain valleys, home of the Tagin, Galo, Nishi, and Apatani communities.

Table 1. Characteristics of communities studied in Assam and Arunachal Pradesh, India

| Community | Study site (District) | Average elevation (m) | Topography ¹⁾ | Annual rainfall (mm) | Original subsistence | Subsistence change | Language | Linguistic group | Population |
|-----------|------------------------------|-----------------------|---------------------------------------|---------------------------|---|--|----------------------------------|---|-----------------------|
| Ahom | Lakhimpur | 50 | Brahmaputra lowland floodplain | 3,350 ²⁾ | Paddy rice cultivation (broadcast-seed system) | — | Assamese | Indo-Aryan | n.a. |
| Mishing | Lakhimpur | 50 | Brahmaputra lowland floodplain | 3,350 ²⁾ | Paddy rice cultivation (broadcast-seed system) | — | Mishing (Adi dialect) & Assamese | Tibet-Burman (Tani language) & Indo-Aryan | 381,043 ⁴⁾ |
| Tagin | Upper Subansiri | 200 | Lesser Himalayan low-elevation valley | 1,900-2,200 ³⁾ | Swidden cultivation on the mountain slope | Introducing paddy rice cultivation since 1950s at the valley | Tagin | Tibet-Burman (Tani language) | 27,122 ⁵⁾ |
| Galo | West Siang & Upper Subansiri | 250 | Lesser Himalayan low-elevation valley | 1,900-2,200 ³⁾ | Swidden cultivation on the mountain slope | Introducing paddy rice cultivation since 1940s at the valley | Galo (Adi dialect) | Tibet-Burman (Tani language) | 8,999 ⁵⁾ |
| Minyong | East Siang | 350 | Lesser Himalayan low-elevation valley | 4,500 ³⁾ | Swidden cultivation on the mountain slope | Introducing paddy rice cultivation since 1940s at the valley | Minyong (Adi dialect) | Tibet-Burman (Tani language) | 25,259 ⁵⁾ |
| Nishi | Lower & Upper Subansiri | 1,100 | Lesser Himalayan mid-elevation valley | 1,000 ³⁾ | Swidden cultivation on the mountain slope | Introducing paddy rice cultivation since 1940s at the valley | Nishi | Tibet-Burman (Tani language) | 56,107 ⁵⁾ |
| Apatani | Lower Subansiri | 1,600 | Lesser Himalayan mid-elevation valley | 1,000 ³⁾ | Paddy rice cultivation (irrigation-transplant system) | — | Apatani | Tibet-Burman (Tani language) | 16,580 ⁵⁾ |

¹⁾ Joshi (2008), ²⁾ Bhagabati et al. (2006), ³⁾ Purkayastha (2008), ⁴⁾ Bhagabati et al. (2001), ⁵⁾ Singh (1995).

ed until 1826. The Ahom community has a long history of paddy rice cultivation; it influenced regional politics, society, and culture in Assam. Currently, the Ahom people speak an Assamese language belonging to an Indo-Aryan subgroup of the Indo-European linguistic family (Bhagabati et al. 2001, Saikia et al. 2007, Asada 2011).

The Mishing people are considered to be a branch of the Adi community group including the Galo and Minyong described below. Although the Galo and Minyong remained in Arunachal Pradesh, the Mishing migrated to Assam in the 17th century (Sahu 2002). Currently, the Mishing practice subsistence paddy rice cultivation combined with the use of fishery skills; they speak both Assamese (Indo-Aryan) and their own language, Mishing. Mishing belongs to the Tani language subgroup of the Tibeto-Burman subfamily of the Sino-Tibetan linguistic family (Sahu 2002, LaPolla and Thurgood 2007).

The indigenous languages of the Tagin, Galo, Minyong, Nishi, and Apatani in Arunachal Pradesh also belong to the Tani language family (LaPolla and Thurgood 2007). The Galo, Minyong, and Mishing languages are dialects of the Adi language, also within the Tani language (Sahu

2002). The Apatani mainly depend and subsist on paddy rice cultivation and live in the Lesser Himalayan valley (Fürer-Haimendorf 1962, Singh 1995, Choudhury and Sundriyal 2003). The communities of Tagin, Galo, Minyong, and Nishi have long been engaged in swidden cultivation on the Lesser Himalayan mountain slopes, while attempts have been made to introduce paddy rice cultivation in the valleys since the middle-20th century. Tani-speaking communities in Arunachal share the custom of raising mithans. The mithan, a semi-domesticated bovid animal (*Bos frontalis*), is essential in their rituals and marriage ceremonies, and is important for other cultural and social occasions (Tara 2008).

People employ two main systems of paddy rice cultivation in the study site (Table 1). The Ahom community uses a broadcast-seed system in the lowland floodplain (Takaya 1987, Asada 2011) (Fig. 2a). They till the soil with two oxen, broadcast seeds (although Sali rice is sometimes transplanted), rely on rain and floodwater, and thresh mature rice by allowing oxen to stamp the grain (Asada 2011). The Apatani community uses an irrigation-transplant system in its mid-elevation valley (Takaya 1987) (Fig. 2b).

They manually till the soil with spades, transplant seedlings, irrigate the fields, and thresh mature rice by beating panicles against a wooden board (Fürer-Haimendorf 1962, Takaya 1987, Ando 2007). The people using these two systems manage irrigation differently based on topography, and this is the main difference between the two systems (Takaya 1987). The sloping mountain valley enables the Apatani people to irrigate their fields by controlling water flow, whereas the flat land and severe flooding from the Brahmaputra River inhibits the ability of Ahom people to create an irrigation system. In contrast, swiddeners in Tagin, Galo, Minyong (on low-elevation mountain slopes), and Nishi (on a mid-elevation mountain slope) grow upland rice on steep mountain slopes. They rely on rainwater, clear and burn vegetation, directly sow seeds without tillage, and harvest by cutting panicles with small knives or by removing the grains manually (Takaya 1987, Tara 2008) (Table 1).

METHODS

Field surveys were conducted in March, July, and August, 2009, in July, 2010, and in March and July, 2011, at the study sites in Arunachal Pradesh and Assam, India. Several surveys, each taking 7–10 days, were administered during those periods.

Semi-structured interviews on cultivation methods were conducted with one to five knowledgeable informants in each village and in 3–12 villages in each community. There were six key informants from Ahom (in Bhogpur, Bordalapa, Mouball, and Nongtu Boruah), four from Mishing (in Dikrong, Gosai Pukhuri, and Naharbari), eight from Tagin (at Digbak, Dugi, and Ligu), and 15 from Galo (in Belo, Bora Ropuk, Doji, Eyi, Kabu, Kaying, Logam Jini, Nyigam, Padi, Pushi Doke, and Tapi). In addition, there were seven from Minyong (in Boleng, Koreng, Gosang, Jengging, Pangin, Pangkang, and Rengo), 20 from Nishi (in Bilo, Deed, Joram, Hawa Camp, Lichi, Lodh, Shallyi, Talo, Tago-Yachuli, Tago-Yazali, Yachuli, and Yazali), and eight from Apatani (in Hari, Hon, and Mudang Tage) (Fig. 1). In addition, a number of other people supplied us with a large amount of information during informal conversations in their homes or during agricultural activities. The co-authors conducted interviews in either Assamese or in Hindi based on the informant's preferred language.

The interview asked for two types of information: the oral history of the introduction of paddy rice cultivation and current cultivation systems. During interviews related to the oral history, the informants were asked about cultivation techniques, their ideas related to swidden and paddy cul-

vation (Table 2), and the sources of rice seed (Table 3); any stories related to paddy rice cultivation were recorded. Interview questions about current cultivation systems were included to establish cropping seasons, rice varieties, and cultivation techniques (nursery, tillage, transplanting, harvesting, threshing, straw disposal, soil improvement, water management, and weed and pest management) (Table 4). Because these techniques differ from place to place or from community to community (Takaya 1987, Tanaka 1987, Watabe 1987), they can serve as appropriate indices of cultivation systems. Further responses recorded the terms for different conditions of rice cultivation, the general terms for weeds, paddy fields and their parts, nurseries, seedlings, water canals, the names of agricultural tools, and one major paddy field weed species (*Echinochloa crus-galli*) in the native language of each community (Table 5). The terms given in the native languages were transcribed phonetically into the English alphabet.

Interviews were followed by direct participatory observation of local paddy rice fields to record the topography and structure, water and soil conditions, weed coverage, cultivation techniques, and rice growth, as well as by sometimes joining in the agricultural activities of transplanting, weeding, and harvesting. This information was cross-checked against previous studies on paddy rice cultivation (Ando 2007, Asada 2011, Fürer-Haimendorf 1962, Fürer-Haimendorf 1980, Saikia et al. 2007, Takaya 1987), and historical records of paddy rice cultivation introduction since 1947 (Elwin 1959, Fürer-Haimendorf 1980, Purkayastha 2008). The authors also visited the Department of Agriculture of the Lower Subansiri District in Ziro and the Arunachal Pradesh Center of the Indian Council of Agricultural Research in Basar to ask about their policies and roles in the agricultural sector.

The collected data on techniques and terms were analyzed to determine the cultural and ecological relatedness among the targeted communities regarding the introduction of paddy rice cultivation. One of the key questions in this study was related to which techniques and terms the local people adopted when paddy rice cultivation was introduced. Does the similarity of the techniques and terms used by Tibeto-Burman language communities depend on their historical linguistic relationships, or has the culture of paddy rice cultivators in Assam had a stronger influence on them? In addition, if not ecologically determined, what effect does the environmental setting have when paddy rice cultivation is newly started?

A cluster analysis was done using nine variables for techniques (Table 4) and 14 for terms (Table 5) concerning paddy rice cultivation to measure the cultural and ecological

relatedness among the targeted communities. Data on the techniques were assigned the numerals 1, 2, or 3 as indicated in Table 4. Similarly, the data on terms were assigned a numeral from 1 to 5 based on advice from linguistic experts: (1) native words in the Tani language; (2) new native words in the Tani language; (3) semantic loanwords; (4) vocabulary loanwords; (5) native words in Assamese. These Fig. s were subjected to cluster analysis using Euclidean distance measures and Ward's method with PC-ORD software version 5 (McCune and Mefford, 2006).

RESULTS

Oral history of the introduction of paddy rice cultivation to swiddeners since the 1940 s

Paddy rice cultivation was introduced to swiddeners beginning in the 1940 s in three administrative regions, which were separated by hilly terrain that hindered communication. This agricultural development program accompanied road construction on three routes. The first is the route from Pasighat to Aalo and northward, in areas currently corresponding to the East, West, and Upper Siang districts. The second route extends from North Lakhimpur to Ziro and currently corresponds to the Papum Pare and Lower Subansiri districts. The third route goes from Aalo or Ziro to Daporijo and currently corresponds to the Upper Subansiri District (Fig. 1). The oral history of the local people in these respective three regions follows.

East, West, and Upper Siang District (Galo and Minyong communities)

Road construction from Pasighat through Aalo to Tuting was initiated in the 1940 s prior to Indian independence. At that time, the local people were engaged in swidden cultivation, and often depended on yams or wild bananas in emergencies when rice was in short supply. Then, the British Government Authority took the initiative to introduce small-scale paddy rice cultivation in the roadside villages. The village headman appointed by the government took charge of this task in each village. Some road construction workers (mostly Nepalese) also built small paddy fields on rented land. However, paddy rice cultivation did not spread among the people because of the difficulty of reclaiming the land with fragile tools made of bamboo and wood.

After Indian independence in the early 1950 s, training

programs introduced paddy cultivation in the villages around Aalo. These training programs were community based, aimed at compelling all the villagers to join in agricultural activities in the common paddy fields that were built for demonstration. The government assigned one village level worker in each village as an instructor. They sometimes threatened rebellious people with fines or jail sentences. The government supplied paddy rice seed and iron spades. Villagers also collaborated in the construction of water canals, and they shared the harvest. However, paddy rice cultivation did not become popular because the villagers preferred swidden cultivation in the mountains to unfamiliar agricultural activities involving working in muddy water (Table 2).

In the 1960 s, training programs for introducing paddy cultivation based on private farming were carried out in the villages around Aalo. The private farming system allowed villagers who created paddy fields to have tenure on the land. Households in the Galo and Minyong communities owned the swidden land, which facilitated their reclaiming of paddy fields. Households without suitable places for paddy cultivation received land from households unwilling to begin paddy cultivation. Immediately after paddy fields were opened by cutting and burning the forest, seeding was done using wooden sticks as was done in swidden fields. Villagers planted both the government-supplied paddy rice and their own upland rice, but the latter did not produce under submerged conditions. Village level workers came to the village as instructors and emphasized that weed growth could be suppressed by making dikes all around the fields and keeping the fields submerged. Irrigation canals built in the 1950 s were extended with long bamboo pipes from distant mountain streams. Pest damage, mostly done by birds, mice, grasshoppers, and worms, was severe in those days because small fields were not in groups but were scattered here and there. For protection, two people stayed in field huts and kept guard at all times during the fruiting period. Only a few people, including the village headman, were willingly engaged in paddy rice cultivation in each village. People from remote villages not visited by village level workers came to see the new agricultural techniques. Those who were deeply interested received information and tools from as far away as Assam when they visited Assam to obtain salt. An older informant remembered that one government officer was a giant man who stayed in Pasighat and Aalo for 5 years and sometimes compelled rebellious men to work by striking them.

In the late 1960 s and 1970 s, the government supplied a high-yield rice variety known as "IR8." Many villagers who had only been engaged in swidden cultivation decided

to start paddy cultivation after observing the high yield of “IR8.” After creating paddy fields, they shifted their houses from the mountains to the valleys, which resulted in the establishment of new villages near the paddy fields. However, IR8 did not taste good, and the yield decreased after 5 years of cultivation. A Taiwanese high-yield rice variety called “Taishun” was also introduced by the government, but did not prevail because of its poor taste.

Oxen were brought from Pasighat with Assamese plows and harrows in the 1980 s to relieve the hard work of tillage. The government also offered subsidies for constructing irrigation canals and terrace fields in the villages.

In the 1990 s, a locally selected rice variety called “Lemuk” became popular in the villages around Aalo because it tasted good and was resistant to pests and diseases. At that time, IR8 was planted only in small areas as grain for making alcohol. The government periodically supplied new

rice seeds, but they always proved to be susceptible to pests and diseases. Villagers collected the rice seeds every year from their own fields, as well as acquiring seeds from friends and acquaintances for trial cultivation. After the government distributed DDT to control malaria, some people used it as a pesticide in paddy rice fields.

Currently, most irrigable land has already been converted into paddy rice fields in this region. The high level of rice production in Boleng allows farmers there to sell rice for cash income. In addition, in Doji village near Aalo, 70 % of all households are engaged in paddy cultivation, but they all also still continue swidden cultivation. To balance swidden and paddy cultivation, cropping seasons are decided based on the swidden agricultural calendar. Work in paddy fields is delayed to avoid overlap during the busiest farming activities because the timing of seeding and harvesting in swidden fields is fixed. One reason for con-

Table 2. Local people's and government's ideas related to swidden and paddy cultivation, before the introduction of the high-yield rice variety IR8 in the 1970s and more recently, after the 1990s in Arunachal Pradesh, India

| | | Swidden | | Paddy | |
|------------------------------------|----------|---|--|--|---|
| | | Government | Farmers | Government | Farmers |
| Before 1970s | Positive | Entire way of life Community unity | Entire way of life High labor productivity | High yield of food grain One step of development together with road construction, formal education, and public health service | Material and financial aid from the government |
| | Negative | Low yield of food grain High mobility of the community Less access to education & public health service | Insufficient food grain | Causing land privatization Prevailing individualism | Inexperience in technique Dislike being submerged Bird & animal damage Shortage of non-rice crop Dislike snake & leech Back pain |
| During 1970s (Green revolution) | Positive | Entire way of life Community unity | Entire way of life High labor productivity | Increase in production with high-yield variety | Increase in production with high-yield variety |
| | Negative | Low yield of food grain | Insufficient food grain | High cost of fertilizer, water and pesticide for high-yield variety | High susceptibility to pest & bad taste of high-yield variety |
| After 1990s | Positive | Conservation of local culture | Production of non-rice crop Preference for the taste of upland rice (the aged) Availability of land Resources in fallow forest | High yield of food grain Sustainable land-use system | Stable & good harvest Preference for the taste of paddy rice (youth) High price of paddy rice & paddy field Symbol of wealth |
| | Negative | Causing forest & land degradation | High risk of poor harvest Long distance to the field Bad taste of upland rice Low yield of upland rice Millet production is not necessary for Christians | Shortage of flat land Much investment needed to make terraces and irrigation canals | Shortage of flat land Insufficient water source Reduced area after inheritance |

tinuing swidden cultivation even after the introduction of paddy cultivation is that little area is available for paddy fields (Table 2). The field area per household shrinks over time because paddies are subdivided among a household's children, which results in shortages of rice for individual household consumption. Another reason is that older people prefer upland rice (Table 2). The older people say that upland rice can be eaten without any side dishes because of its familiar sweet taste, but the younger generation prefers paddy rice.

Papum Pare and Lower Subansiri District (Nishi and Apatani communities)

Among the Nishi community, people first started paddy rice cultivation in Joram where a flat plain spreads near the paddy field area of the Apatani community. Villagers said that small-scale paddy fields were cultivated with spades made of wood and mithan bone prior to Indian independence.

In the 1950 s, the government sent some Nishi farmers to Apatani in Ziro and Ahom in North Lakhimpur to learn paddy rice cultivation. At the same time, village level workers supplied iron spades and weeding tools; they taught locals how to construct terraces and waterways in the village fields. Nishi had been using swidden cultivation on its communal hilly land, but reclamation of paddy fields in the valley caused land privatization. They constructed terraces and waterways collaboratively, and then divided the fields

among those who had participated. They planted their own upland rice or rice acquired from the Apatani community (Table 3). Nishi had a trading relationship with neighboring paddy rice cultivators in Apatani and Ahom, which encouraged its transformation from swidden agriculture. However, only a small number of people, mostly village leaders or people with initiative, participated in paddy rice cultivation in the village, because the Nishi disliked paddy tasks such as bending over in muddy fields, and because paddy fields did not produce non-rice crops such as finger millet, foxtail millet, maize, yams, taro, beans, gourds, and other vegetables (Table 2).

They mainly collected rice seeds in their own fields, but also acquired some from nearby villages, the agricultural department, or even from foreign countries visited by acquaintances. Those that were suitable to the locality were selected by trial and error. The government supplied the high-yield IR8 in the late 1960 s and 1970 s. Since the late 1980 s, the Nishi community has cultivated mostly varieties that originated in Assam, and one high-yield variety from the agricultural department in Basar (Table 3). The remarkably high yield of newly introduced paddy rice varieties induced many Nishi people to transform their way of subsistence. As the people came to possess additional paddy fields in the valley, more of them moved from the mountains to the valleys. In addition, the Apatani community continues to plant mostly their own traditional bearded rice, although they sometimes use varieties from the Assam and Nishi communities in small areas, especially after pest or disease damage.

Table 3. Paddy rice varieties cultivated in Joram (Nishi community), Arunachal Pradesh, India

| Variety | Period ¹⁾ | Yield ²⁾ | Origin | Characteristics |
|------------------------|----------------------|---------------------|---------------------------|---|
| <i>Current variety</i> | | | | |
| Basar | 90 | 3.8 | Basar | High-yield variety derived from Basar Agricultural Department. Highest yield, and grain has good smell. |
| Yater | 90 | 2.5 | Assam | Grain is smallest. |
| Chalacky | 120 | 2.8 | Assam | Tallest height, with many tillers and thick straw. |
| Lahi | 120 | 1.3 | Assam | Grain is regarded as being the most delicious although the yield is lowest. |
| Yayum | 120 | 3.1 | Assam | Husk has awn. |
| Sala | 135 | 2.9 | Assam | Grain is largest. |
| <i>Former variety</i> | | | | |
| Kapa | n.a. | 1.3 | Own swidden field or Ziro | Similar to Apatani variety. |
| Taba | n.a. | 1.3 | Own swidden field or Ziro | Similar to Apatani variety. |
| Papum | n.a. | 1.3 | Own swidden field or Ziro | Similar to Apatani variety. |
| Pyare | n.a. | 1.3 | Own swidden field or Ziro | Similar to Apatani variety. |

¹⁾ Growing period (days), ²⁾ Yield (ton per hectare), based on interview surveys.



Fig. 2. People and landscapes in paddy rice fields in Arunachal Pradesh and Assam. (a) Paddy rice cultivation with oxen at Ahom and Mishing on the Brahmaputra floodplain, Assam. (b) Irrigated field with finger millet on the berms in Apatani. (c) New paddy field on a dry rocky slope at Nishi. (d) Manual tilling in Minyong. (e) Weeding *Echinochloa crus-galli* in Nishi. (f) Harvesting of paddy rice using a swidden technique at Galo.

The Nishi farmers followed Apatani manual tillage methods when they introduced paddy rice cultivation. However, they started to adopt ox, plow, and harrow techniques from Assam in the 1970 s, 1980 s, or later, after observing the higher efficiency of animal-powered soil tillage (Fig. 2a, Fig. 2c). Nishi people contracted with a trainer who had oxen and a plow from Assam for a month during the plowing season because non-trained oxen could not pull plows in paddy fields.

Currently, 90 % of all households are engaged only in paddy rice cultivation, and the remainder are active in both

swidden and paddy cultivation in Yachuli, where flat land and road access are available. Some of the Christians who form the dominant religion in Yachuli say that some of the Christians who do not drink alcoholic beverages do not need swidden fields, because those fields are used to produce finger millet for making alcohol (Table 2).

Upper Subansiri District (Tagin, Nishi, and Galo communities)

Daporijo town had no paddy fields when it was established in the valley in 1952–1953. Small-scale paddy cultivation began in Daporijo after government officers came and conducted training programs in the late 1950s.

Ligu village, currently located in the valley near Daporijo town, was on the mountain where Tagin and Nishi were engaged in swidden cultivation. In 1967–1968 when the village school was constructed in its current location, the area was still surrounded by forest and customary land tenure had not yet been established. In 1969, government officers visited the area with the high-yield rice variety IR8 and promoted paddy rice cultivation. Then, the people of Tagin and Nishi came down from the mountain, reclaimed paddy fields, and occupied the plains in the valley. Since that time, Ligu village has been composed of both Tagin and Nishi residents. They planted IR8 as well as their own upland rice seeds in the newly opened fields. The high yield of IR8 decreased after 5 years of cultivation. When they visited Silapathar, Dhemaji, or North Lakhimpur in Assam to trade dried bamboo shoots for salt, they also brought oxen and iron spades. Some people learned paddy cultivation techniques at Aalo on their own. Currently, almost all the households are engaged in paddy cultivation. They collect rice seeds in their own fields or acquire them from acquaintances because the rice varieties supplied from the government do not grow well. Nishi swiddeners living on the mountains often come to Ligu village to exchange their finger millet for paddy rice, because finger millet is still important for making alcohol in the village.

Digbak village, currently located in the valley near Daporijo, was on the mountain prior to 1969 where Tagin people were engaged in swidden cultivation. In 1969, when village level workers from Aalo came to promote paddy rice cultivation, they relocated and settled in the current location. Village level workers introduced IR8 and instructed the village headman to encourage villagers to start paddy cultivation. The village headman also visited Aalo and Pasighat to learn cultivation techniques. The villagers worked cooperatively to construct irrigation canals. Villagers reclaimed swampy land that no one used at that time. The people who created the paddies were granted tenure on them. When many people began to occupy the plains, border conflicts arose among neighboring villages. Then, the village headman of the nearby villages of Tagin, Nishi, and Galo met to settle the border conflict, sacrificing two mithans and eating together.

Belo village was established in 1958 by Galo immi-

grants who could not obtain land suitable for paddy cultivation in their original home area near the Siang River. The indigenous Tagin and Nishi people granted the village land, and a border was delineated. Villagers cleared and burned the forest, and planted their own upland rice seeds in the first few years. In 1963, following the instruction of village level workers, they created paddy fields in the land cleared for swidden cultivation the previous year, and constructed an irrigation canal. They planted both IR8 and upland rice, but the latter did not bear well under submerged conditions. In the same year, oxen were brought from Silapathar by helicopter to till the soil. The government also supplied iron spades, picks, oxen, and plows in 1967–1968. Persons certified as “best farmers” were awarded agricultural tools as prizes. Soils were tested in 1970–1972, and the government distributed chemical fertilizer as needed. Currently, all the households are engaged in paddy cultivation, but the fields become smaller and smaller after being subdivided among the children in some households.

Common features of the three regions

Despite their differences, these regional introductions exhibit several similarities.

Some interviewees mentioned the government campaign to restrict swidden cultivation, in which village level workers and local political leaders participated. However, there was no compelling force to achieve the purpose. In addition, after creating paddy fields in the valley, local people moved from the mountains to the valleys near the paddy fields. The government would certify any settlement of at least 10–15 households as a village and then provided assistance in establishing a school as well as providing water and electricity, which served as a force pulling more people down from the mountains.

All the swiddener communities introduced animal power tillage systems from Assam. In the period of transition from human to animal power, households without trained oxen hired young men to pull plows and harrows (Fig. 2d). Although Tani-speaking communities in Arunachal owned mithans, they never used them for agricultural work because they are valuable property, tire easily, and are sensitive to heat.

There are two work patterns in paddy cultivation. Villagers repair and clean communal irrigation canals collectively. Individual households or groups of relatives and neighbors transplant, weed, and harvest the crops. When collective work is done on private paddy fields, the owner offers food and alcohol to all the participants. The participants all

help each other to conduct agricultural activities. This collaborative work with relatives and neighbors does not involve wages, but the group arranges the time each person works so it is equal for all the participants. Some wealthy households also hire workers in the busiest farming season.

Someone unintentionally introduced a paddy field weed, *Echinochloa crus-galli*, with rice seed brought from Assam. Farmers report that they must weed fields one to three times each growing season to eliminate this major pest (Fig. 2e). Oxen brought from Assam probably introduced a spiny weed, *Solanum viarum*. While villagers rarely use herbicides in paddy fields, they sometimes use pesticides to control locusts, stink bugs, or small worms. Although various cultivation techniques were introduced from paddy cultivating communities, swiddeners have adapted their own traditional tools and techniques such as harvesting knives, carrying baskets (Fig. 2f), mousetraps, and weeding tools. Villagers sometimes burn rice stubble and weeds immediately after the harvest. Villagers in this area usually continue some aspects of swidden cultivation growing vegetables, fruits, and millet, and gather other natural resources (Table 2).

Most interviewees reported that they appreciated the high productivity and taste of rice grown by paddy cultivation. In good years, they can sell paddy rice for cash, especially after the government implemented a ration system that ensured food grain prices remained reasonable for local people in the 1990s. However, older people prefer swidden

cultivation work and the taste of upland rice (Table 2). Villagers also reported cultivation is difficult given the shortage of suitable gently sloping land and limited water supplies (Table 2). Small plots with stony soil on steep slopes were difficult to till and plant. Water shortages have caused some fields, which had been previously reclaimed with government support, to be abandoned. In contrast, excessive water hinders cultivation of some fields. Farmers reported that fields with waist-deep water are difficult to work. Nevertheless, farmers generally agree that paddy rice fields, reclaimed and maintained by overcoming such difficulties, serve as a sign of wealth and a source of social status (Table 2) partly because of the high stable yield of paddy rice. In addition, paddy fields are considered private land and may be targeted for land sales providing the owners with another source of income. Recently, the escalating land prices, especially for flat land near towns and main roads, have enabled landowners to obtain a large amount of capital.

Comparing the communities' current cultivation systems

Cropping seasons and the number of crops per year vary in each community. Two or more crops per year can be grown in Ahom, Mishing, and Galo (Fig. 3, Table 4). Ahom and Mishing grew "Bao" rice in deep-water fields along rivers using the broadcast-seed method; "Ahu" rice was

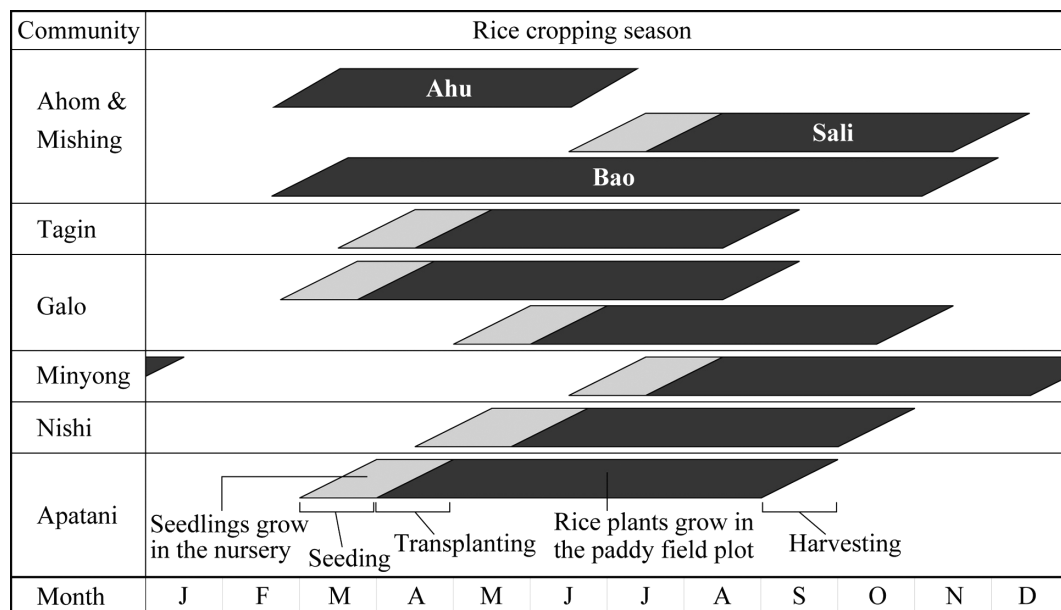


Fig. 3. Paddy rice cropping season at the study sites. The pale gray bar indicates nursery growth, and the dark gray bar shows growth in the paddy after transplantation. In the Ahom and Mishing communities, Ahu and Bao rice are broadcast sown, without using a nursery.

grown in shallow water fields by broadcast-seed between March and July followed by “Sali” rice grown by transplantation in July. In Galo, farmers sowed early rice in March and sometimes sowed late rice in May. Tagin, Minyong, Nishi, and Apatani cultivated one crop per year from March to June (Fig. 3).

The various communities had major differences in their methods of cultivation, nursery, tillage, transplanting, harvesting, threshing, straw disposal, soil improvement, and water source techniques (Table 4). Most communities prepare a wet nursery beside a paddy field, but in Minyong and Nishi, they establish a dry nursery on a fertile hill slope by burning the vegetation then tilling with spades, because this type of dry nursery allows seedlings to be easily removed for transplanting. In these communities, early tilling is suppressed. The slow growth allows farmers to keep the seedlings in the nursery for as long as 2 months when water shortages delay transplanting. Swiddener communities that did not use oxen and plows prior to the 1960s imported these techniques from Assam. Arunachal communities transplant only one seedling in each spot, whereas Assam communities plant several seedlings together. Although Arunachal communities had previously harvested paddy rice by cutting the panicle from the stem with a small knife (Fig. 2f), Nishi and Apatani farmers started harvesting entire plants with sickles introduced from Assam. Harvested rice was threshed by oxen or by men stamping on it except in Nishi and Apatani where rice panicles were beaten against wooden boards. Rice straw disposal differs depending on harvesting and threshing methods, and its intended use. In Ahom and Mishong, farmers kept rice straw in ricks in the garden to feed livestock, whereas in Nishi and Apa-

tani they scattered it on their fields. Apatani differed from other communities by fertilizing paddy fields with manure and by cultivating finger millet on the dikes (Table 4, Fig. 2b). Although the Nishi people learned paddy cultivation techniques from the Apatani, they do not grow finger millet on the dikes because they plant it in vast swidden fields in the mountains.

Each community also used a variety of different terms for paddy rice cultivation (Table 5). Ahom farmers used native Assamese words in their cultivation vocabularies. In addition, Tibeto-Burman-speaking communities differed in the extent to which they used loanwords from Assamese or Nepalese. They used their native words for different conditions of the rice, and the general terms for weeds and field patches. Semantic loanwords for paddy rice fields were used in Tibeto-Burman communities except in Apatani, where they used the native word. Native words for field dikes and *E. crus-galli* were used in Tibeto-Burman communities except in Mishong, where loanwords were used. The words for nursery, seedling, water canal, and various agricultural tools were mostly loanwords in most communities, but less so in Apatani and Nishi. As a result, Apatani farmers used the largest number of native words, followed by people in Nishi among the Tibeto-Burman-speaking communities (Table 5).

Grouping community cultivation systems by cluster analysis

A dendrogram (Fig. 4) was produced using cluster analysis of the Fig. 3 assigned to the various techniques

Table 4. Paddy rice cultivation techniques by community in Assam and Arunachal Pradesh, India

| Community | Ahom | Mishong | Tagin | Galo | Minyong | Nishi | Apatani |
|--------------------|-------------------------------------|-------------------------------------|------------------------------|------------------------------|------------------------------|---------------------------------|---------------------------------|
| Cropping season | 2 times ² | 2 times ² | 1 time ¹ | 2 times ² | 1 time ¹ | 1 time ¹ | 1 time ¹ |
| Nursery | Wet ¹ | Wet ¹ | Wet ¹ | Wet ¹ | Dry ² | Dry ² | Wet ¹ |
| Tillage | Ox ¹ | Ox ¹ | Man to Ox ² | Man to Ox ² | Man to Ox ² | Man to Ox ² | Man ³ |
| Transplanting | More than one seedling ² | More than one seedling ² | One seedling ¹ | One seedling ¹ | One seedling ¹ | One seedling ¹ | One seedling ¹ |
| Harvesting part | Stem ¹ | Stem ¹ | Panicle ³ | Panicle ³ | Panicle ³ | Panicle to Stem ² | Panicle to Stem ² |
| Threshing | Stamping ¹ | Stamping ¹ | Stamping ¹ | Stamping ¹ | Stamping ¹ | Beating ² | Beating ² |
| Straw disposal | Kept in rick ¹ | Kept in rick ¹ | Remain as stump ³ | Remain as stump ³ | Remain as stump ³ | Scattered in field ² | Scattered in field ² |
| Soil fertilization | No input ¹ | No input ¹ | No input ¹ | No input ¹ | No input ¹ | No input ¹ | Manure ² |
| Water source | Rain & flood ¹ | Rain & flood ¹ | Irrigation ² | Irrigation ² | Irrigation ² | Irrigation ² | Irrigation ² |

The data were assigned to figures (1–3; shown in the upper-right of each datum) for cluster analysis.

Table 5. Specific terms related to paddy rice cultivation by community in Assam and Arunachal, India

| Community | Ahom | Mishing | Tagin | Galo | Minyong | Nishi | Apatani |
|------------------------|-------------------------|--------------------------|------------------------|-----------------------------------|----------------------------|-------------------------|------------------------------|
| Rice (plant) | Dhan ⁵ | Am ¹ | Am ¹ | Amo ¹ | Ammo ¹ | Am ¹ | Emo ¹ |
| Rice (husked grain) | Chawal ⁵ | Ambin ¹ | Ambin ¹ | Ambin ¹ | Ambin / Dobin ¹ | Embin ¹ | Ambin ¹ |
| Rice (cooked) | Bhat ⁵ | Apin ¹ | Achin ¹ | Achin ¹ | Apin ¹ | Achin ¹ | Apin ¹ |
| Weed | Bon ⁵ | Eung ¹ | Eu ¹ | Eu ¹ | Eung ¹ | Eu ¹ | Tami ¹ |
| Paddy field | Pani Kheti ⁵ | Ashi Arak ³ | Eus Nongo ³ | Isi Ruku / Pata Ruku ³ | Ashi Arik ³ | Sepa Rongo ³ | Aji ¹ |
| Field patch | Ruwa Toli ⁵ | Dora Aborko ¹ | Safar ¹ | Sipe / Hipe ¹ | Sipeng / Pako ¹ | Para ¹ | Aji ¹ |
| Field berm | Ali ⁵ | Ali ⁴ | Geuv ¹ | Pegu / Dape ¹ | Dapi / Nive ¹ | Pagar ¹ | Agar ¹ |
| Nursery | Kotia Toli ⁵ | Kotia Toli ⁴ | Am Pak ³ | Kotia Piko ⁴ | Koti Pitkang ⁴ | Ampa Polu ³ | Midding ¹ |
| Seedling | Kotia ⁵ | Kotia ⁴ | Amso ¹ | Kotia ⁴ | Koti ⁴ | Ampa ¹ | Endi ¹ |
| Water canal | Naa Laa ⁵ | Abung ¹ | Naa Laa ⁴ | Nola ⁴ | Nola ⁴ | Silam ¹ | Suling / Segang ¹ |
| Plow | Nangol ⁵ | Nangol ⁴ | Nangol ⁴ | Nangol ⁴ | Nangol ⁴ | Nangol ⁴ | Nangol ⁴ |
| Spade | Kor ⁵ | Kuyap ⁴ | Kar ⁴ | Kutar ⁴ | Pakur ⁴ | Kholi ⁴ | Dipe ¹ |
| Sickle | Kasi ⁵ | Kasu ⁴ | Kasi ⁴ | Kasi ⁴ | Kasi ⁴ | Tagi ¹ | Tagi ¹ |
| <i>E. crus-galli</i> | Binoi ⁵ | Binoi ⁴ | Yugom Am ² | Yagum Am ² | Mihuk Amyuk ² | Goro Amso ² | Tago Enso ² |

For cluster analysis, the data were assigned numerals (shown in the upper-right of each datum) as follows: (1) pre-existing native words in the Tani language; (2) new native words in the Tani language; (3) semantic loanwords; (4) vocabulary loanwords; (5) native words in Assamese.

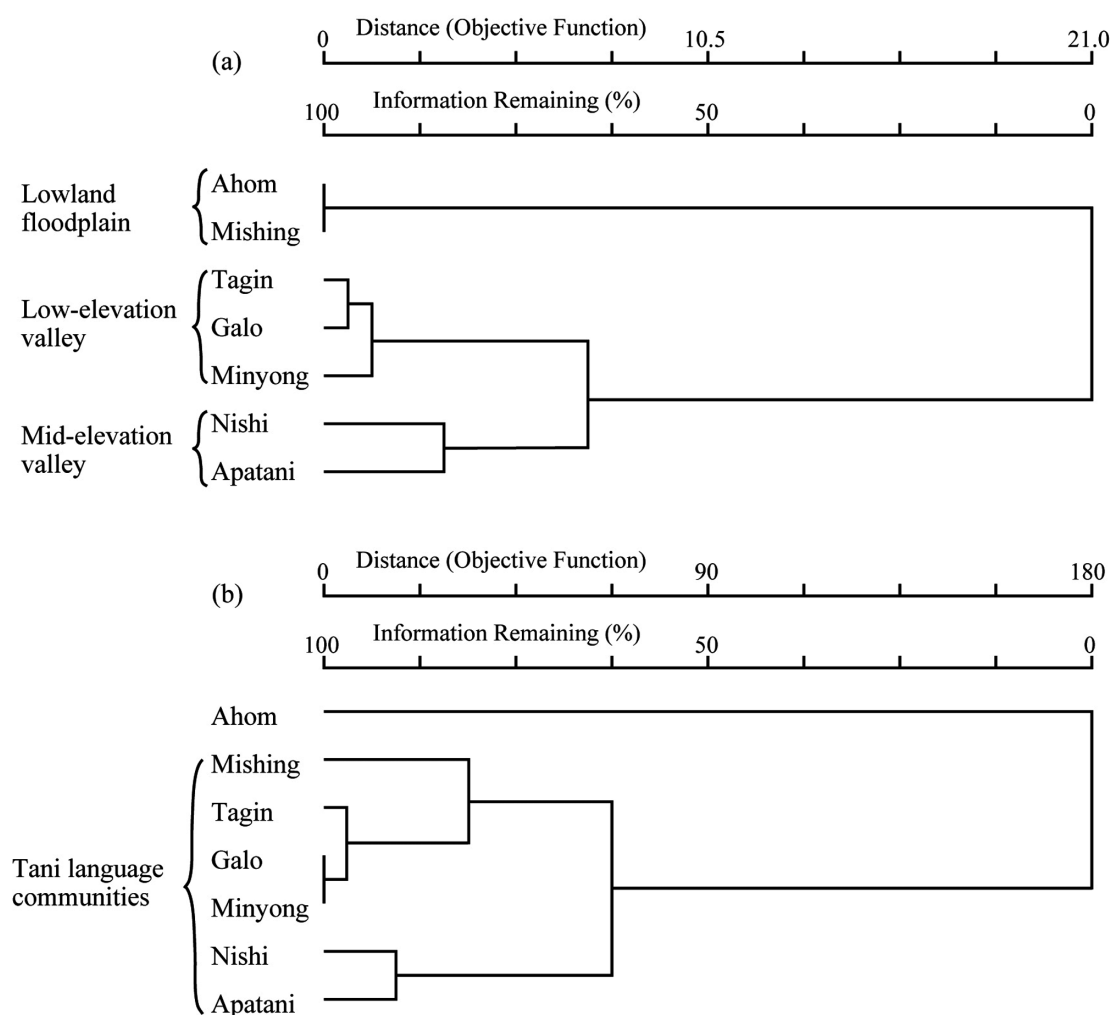


Fig. 4. Cluster analyses of (a) cultivation techniques and (b) specific terms related to paddy rice cultivation.

(Table 4) and terms (Table 5). Cultivation techniques were classified into the three groups that corresponded to the cultural and environmental settings of the communities. The lowland floodplain group, Ahom and Mishing, characteristically used oxen for tillage, transplanted more than one seedling, kept straw in ricks, and depended on water from rain and flooding. The low-elevation valley group, Tagin, Galo, and Minyong, characteristically harvested panicles and left straw stubble in the field. The mid-elevation valley group, Nishi and Apatani, characteristically used beating-style threshing and scattered straw in the fields (Table 4, Fig. 4a). The farming techniques of the Tagin-Galo-Minyong and Nishi-Apatani groups, who lived in mountainous areas, differed from the lowland floodplain group of Ahom and Mishing (Fig. 4a).

Cultivation terms were clustered into one large group of Tibeto-Burman speaking communities, except for the Ahom community, which used native Assamese words (Fig. 4b). Although the Galo, Minyong, and Mishing languages are dialects of the Adi language, Mishing was clustered outside because of their frequent use of loanwords from Assamese (Table 5). Nishi and Apatani had their own native words for seedling, water canals, and sickles, and therefore were classified separately into a group (Fig. 4b).

DISCUSSION

The consequences of government support and the green revolution

In Arunachal, swidden transformation generally occurred when most local residents decided to start paddy rice cultivation after realizing the high productivity of a high-yield rice variety supplied by the government. A synergetic effect was observed when less animal and insect damage occurred as the paddy fields expanded. The more people gathered to live near the paddy fields, the more the government invested in infrastructure. This trend in expanding paddy fields occurred simultaneously in many Asian countries during the so-called “green revolution.” The International Rice Research Institute created the very productive IR8 variety in 1966. Often called “miracle rice,” IR8 triggered the “green revolution” in Asian rice production (Shiva 1992, Masuda 1995). In India, the cropping area of high-yield rice variety increased dramatically from 2 % of the total rice cropping area in 1967 to 69 % in 1988 (Masuda 1995).

The transition has not always been easy. Elwin (1959) reported that wild elephants, which never harmed swidden

fields, damaged paddy fields and limited production. In addition, while rice production may have increased wealth, field conversion may have reduced the vegetable supply. It takes many years and much labor input to construct the better paddy fields with well-managed canal and less permeable soil (Padoch et al. 1998). The introduction of permanent cultivation provided incentives for the privatization of communal land, which could disrupt the local political and social system. The anxiety related to embarking on land privatization and individualism (Elwin 1959) was reflected in the trial of community-based farming in the 1950s near the Aalo community, which failed to become popular. Instead, private land tenure became an incentive for local people to create paddy fields. In the early times, local people chose to not participate in paddy cultivation because they thought swidden cultivation required less labor and was more productive (Table 2). Scientific research confirmed this local feeling (e.g., Boserup 1965). Paddy fields produce high rice yields through intensive labor input; however, this results in higher productivity per unit of land area, but not per unit of labor. The shortage of land suitable for paddy cultivation provides the main reason for continuing swidden cultivation (Table 2). In addition, a great deal of communal land continues to be suitable for swidden cultivation even after the expansion of private land use for paddy and maize fields and for bamboo groves (Fürer-Haimendorf 1980). Combining paddy fields with swiddens in a single subsistence system is suitable for meeting the needs of the local community and relieves some of the pressure to clear more forest (Fox et al. 2000). The government program of introducing terrace rice cultivation in Meghalaya in northeast India in 1974–1976 (Rasul and Thapa 2003) provides a comparison to this study site. This program failed because not enough suitable land was available for terracing, the plots were small and scattered, few roads linked the plots, and the cost of constructing irrigation canals was prohibitive (Rasul and Thapa 2003). In other cases of swidden transformation in Asia, swiddeners are adopting new practices and engaging in new markets, but in many situations swiddening still is important to the livelihood strategies of local people, providing resilience against vulnerability and marginalization in market economies and a way to hedge against government intervention (e.g., Cramb et al. 2009).

Agrarian differentiation is an important issue in swidden transformation in Asia (Li 2002, Cramb et al. 2009), and occurred in the swiddener communities in Arunachal. In our study sites, land privatization served as the main trigger for differentiation, followed by land sales and escalating land prices, especially for the flat land near towns and main roads. The considerable time and labor cost of constructing

terraces and irrigation canals on steep mountain slopes allow only wealthy households to create paddy fields (Ramakrishnan 1992), which may stabilize or expand a communities' socio-economic differentiation. As a result, paddy fields are currently a symbol of wealth and social status among the swiddener communities in Arunachal (Table 2), as are new crops for small upland landholders in other regions in Asia (e.g., Li 2002).

Human-environment interactions represented in paddy rice cultivation

Swiddeners' paddy rice cultivation techniques in Arunachal were not exactly equal to those practiced by neighboring paddy rice cultivators, specifically, the Ahom in Assam and the Apatani in Arunachal. The differences observed in swiddeners' rice cultivation had resulted from interactions between humans and the local environment. Although six communities belong to the same linguistic group (Table 1, Fig. 4b), each developed cultivation techniques that are adapted to their local culture and environment (Fig. 4a). All three cultivation systems (irrigation-transplant, broadcast-seed, and swidden, Takaya 1987) showed some differences between communities (Table 4). A detailed analysis of each technique, formed through human-environment interaction, is described below.

The growth of different varieties of rice is constrained by temperature, day length, water conditions, and pests and diseases; these conditions vary in each locality (Fukui 1987, Nakagawara 1987, Watabe 1987). After pests and disease damaged the high-yield variety supplied by the government, the large number of diverse rice varieties available in Arunachal and Assam (Hedge 2003, Bhagabati et al. 2006, Saikia et al. 2007, Asada 2011) aided the swiddeners' selection of varieties suited to their local environment (Table 3). Shiva (1992) pointed out that most Indian farmers preserved their own rice varieties separately from the high-yield varieties, and exchanged them with each other even during the "green revolution."

As occurred in other regions of Asia, the natural environment serves as the main factor that determines cropping seasons (Fukui 1987, Tanaka 1987). For example, two crops of rice can be cultivated annually in the warm low-elevation areas of Ahom, Mishing and Galo (Fig. 3, Table 4). In addition, the colder Apatani community plants rice earlier than the warmer Minyong community does because abundant water from a well-managed irrigation canal irrigates Apatani fields (Fig. 2b, Fig. 3).

Villagers now employ more efficient cultivation tech-

niques. Swiddeners started using animal-powered tillage (Table 4, Fig. 2c) because it is more efficient than manual tillage except in deep-water fields or on small terrace plots on steep slopes (Tanaka 1987). The harvesting method in Nishi and Apatani has also changed from cutting panicles with small knives (Fig. 2f) to cutting a bunch of stems with a sickle. This practice, a widespread trend in Asia, made possible by the introduction of uniformly fruiting rice varieties (Takaya 1987, Tanaka 1987). Villagers growing paddy rice do not remove grains manually as is done with swidden harvesting because paddy rice has a hard rachis.

The method of threshing rice by beating the rice panicles observed in Nishi and Apatani (Table 4) is also widespread throughout Asia, and may be related to the introduction of rice varieties with grains that fall easily (Tanaka 1987). Stamp threshing, used in swiddener communities (Table 4), occurs in regions where rice is still harvested by cutting panicles (Tanaka 1987). Villagers mainly thresh rice in Ahom by having oxen stamp on the panicles (Asada 2011), which is typical in broadcast-seed type cultivation (Takaya 1987, Tanaka 1987).

The dry nurseries on hill slopes used in Minyong and Nishi were unique (Table 4), although other regions in Asia dominated by swidden cultivation also employ dry nursery techniques (Tanaka 1987).

CONCLUSION

We analyzed the swidden transformation of Tibeto-Burman communities in Arunachal since the 1940s, based on their oral history and the techniques and terms they use that relate to newly introduced paddy rice cultivation.

The oral history revealed the common features employed during swidden transformation among the three administrative regions. Material and financial support from the government promoted the change from swidden to paddy cultivation. Many swiddeners decided to start paddy cultivation after observing the high yield of new rice variety, IR8, which caused the "green revolution" in Asian countries in the late 1960s and 1970s. The government also improved the infrastructure needed for farmers in settlements of a certain size in the valleys, which served as a pulling force for more people to relocate from the mountains to the valleys. Currently, paddy fields serve as a symbol of the wealth and a source of social status, because paddy rice provides a high and stable yield and because land prices continue to escalate. Agrarian differentiation, a common event in swidden transformation in Asia, also occurs via land privatization followed by land sales in the area we

studied.

Although government initiatives promoted swidden transformation, swiddeners did not introduce paddy rice cultivation by blindly following the government's instructions. Tibeto-Burman language-speaking communities use similar terms for paddy cultivation, but they developed different cultivation techniques that are best suited to their local environment over 60 years of trial and error. The spontaneity and creativity of local farmers played an important role in the formation of techniques through human-environment interaction. This includes the spontaneous learning of techniques from acquaintances such as those people they traded with and those who were neighboring paddy rice cultivators. Farmers selected suitable rice varieties for their unique environments after the yield of the government-supplied variety decreased, and they incorporated swidden skills and tools into paddy cultivation. Swidden cultivation still serves as an important means of subsistence given the demand for non-rice crops and the shortage of suitable land for paddy cultivation. Future agricultural extension services and development programs will be effective if they incorporate the spontaneity and creativity of skilled local farmers.

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